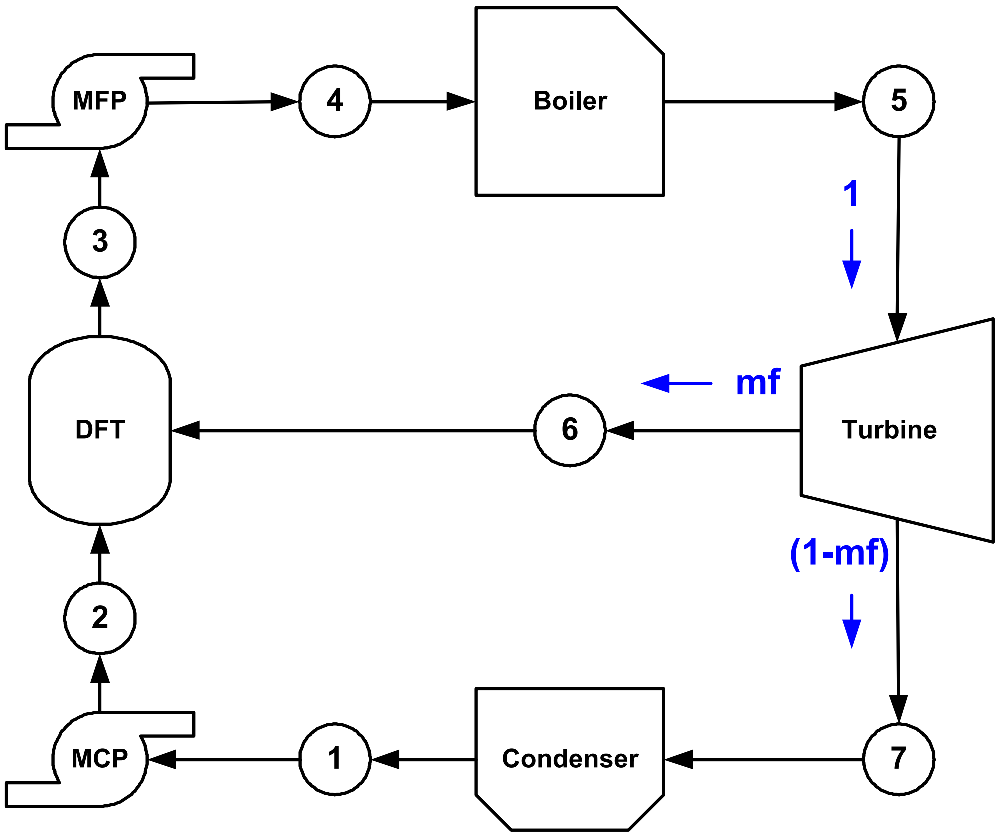
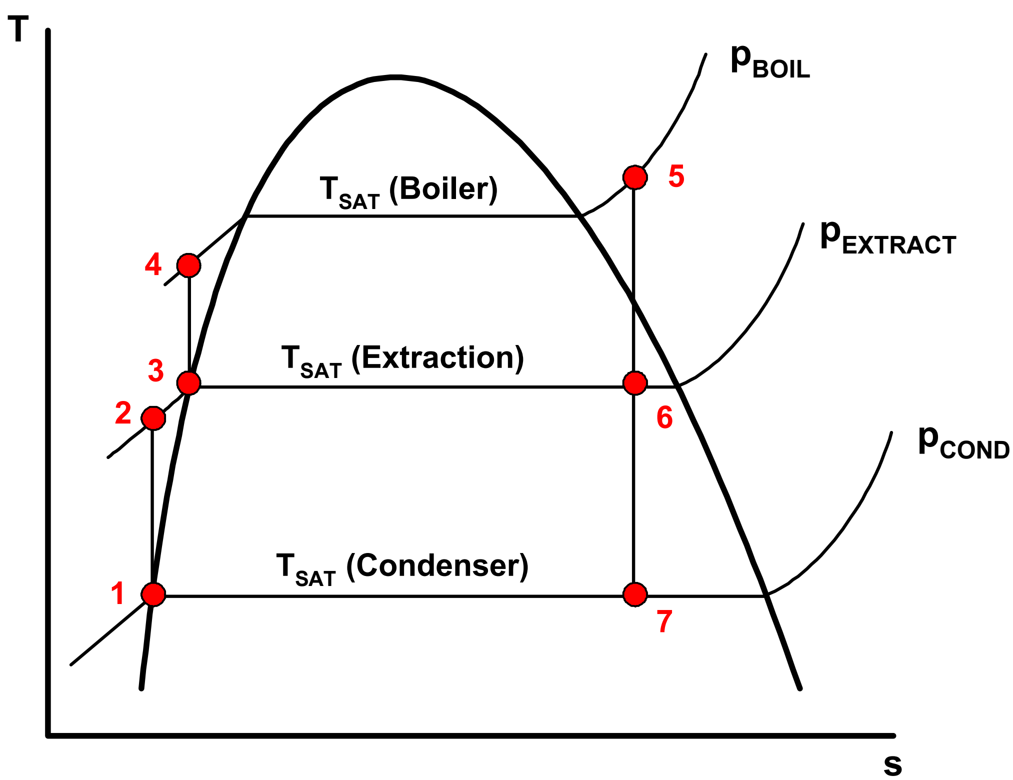
STEAM REGENERATION PLANT



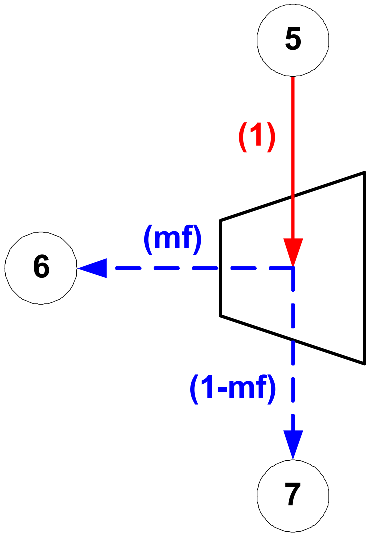
A certain mass fraction (mf), which is just a percentage of the steam entering the turbine, is extracted from the turbine at a certain pressure p_6. This extracted steam is the heating source for the DFT. The thermal energy of this extracted steam is used in the DFT (a heat exchanger). As a result of this extraction, the turbine has less thermal energy available for turbine work (i.e. w_{OUT})



REGENERATION EFFECTS

The extraction of steam (regeneration) has some noticeable effects on the steam plant:

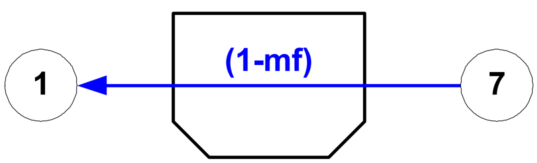
1) Reduces the amount of turbine work.



$$w_T = (h_5 - h_6)(1) + (h_6 - h_7)(1 - mf)$$

This turbine work reflects that all of the steam (1) contributes to turbine work from 5 → 6 and that only that portion which was not extracted (1 – mf) contributes to the rest of the turbine work from 6 → 7.

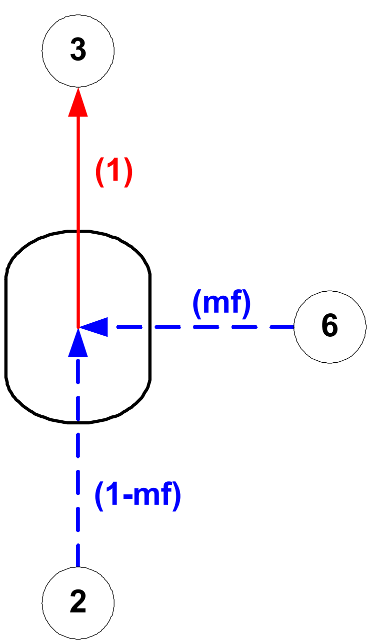
2) Reduces the amount of heat rejected in the condenser.



$$q_R = (h_7 - h_1)(1 - mf)$$

Only the portion (1 – mf) passes through the condenser.

3) Provides a heat source to the DFT.



A heat balance (what comes in equals what goes out) of the DFT reveals what mass fraction (mf) is required at the extraction pressure p_6:

$$(h_2)(1 - mf) + (h_6)(mf) = h_3(1)$$

then, solving for the mass fraction (mf):

$$mf = \frac{h_3 - h_2}{h_6 - h_2}$$

This mass fraction is just the % of steam extracted from the turbine – it does not contribute to turbine work, instead its' energy is used as heat in the DFT.

REGENERATION: ADDITIONAL CONSIDERATIONS

PUMP WORK:

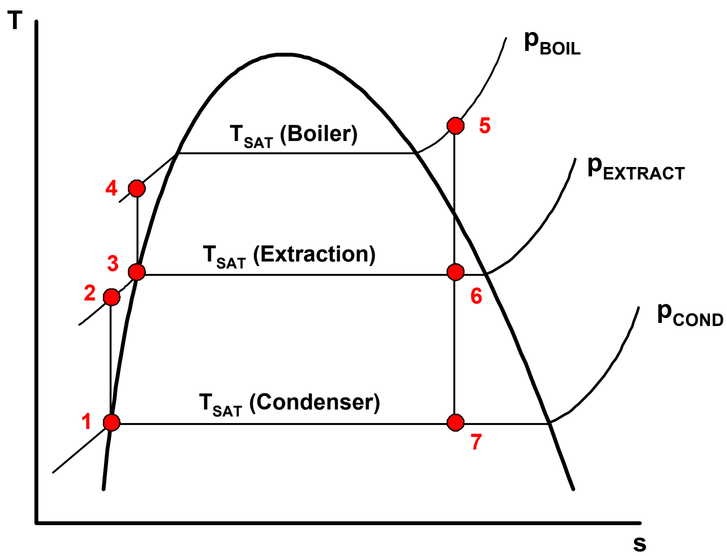
There are two pumps in this cycle: 1) Main Condensate Pump (MCP) and 2) Main Feed Pump (MFP). Both are WORK IN components – so be sure to calculate the work of both pumps in calculating total pump work (i.e. figuring out net work).

$w_{MCP} = (h_2 - h_1)(1 - mf)$ ← **Notice only the portion (1 – mf) runs through the MCP**
$w_{MFP} = (h_4 - h_3)$
$w_P \text{ (total)} = w_{MCP} + w_{MFP}$

thus, net work of the regeneration plant: $w_{NET} = w_{OUT} - w_{IN} = w_T - w_P \text{ (total)}$

OPTIMUM EXTRACTION PRESSURE:

While the problem statement may specify a specific pressure at which steam is extracted for the regeneration process, there is also a way to calculate the "optimum" pressure (p_6) at which the steam should be extracted.



To calculate this optimum steam extraction pressure, find the saturation temperatures in the boiler and the condenser: the saturation temperature at which steam should optimally be extracted is halfway between those temps:

$$T_{SAT} \text{ (Extraction)} = \tfrac{1}{2} [T_{SAT} \text{ (Boiler)} + T_{SAT} \text{ (Condenser)}]$$

Finally, enter steam table 1 and find (or interpolate) the pressure that corresponds to the T_{SAT} (Extraction) you just calculated. You have just found the optimum extraction pressure.